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Technology-Based Interventions for Preventing Youth Violence: A Systematic Review of Programs, Tools, and Evidence

Concetta Esposito[1] · Federica De Masi[1] · Mirella Dragone[2] · Dario Bacchini[1]

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Abstract

Digital interventions have emerged as a promising tool for preventing youth violence, although the evidence base supporting their effectiveness lacks a cohesive framework. The aim of this review was to consolidate existing strategies for preventing youth violence through technology, providing insights into the current landscape, emerging trends, gaps, and the effectiveness of these strategies. Several databases were searched for evaluation studies of digital interventions specifically designed for children and adolescents up to the age of 18, without imposing any restrictions on the publication dates (e.g., APA PsycArticles, APA PsycInfo). The methodological quality of the included studies was appraised using the Mixed Methods Appraisal Tool. The review covered 26 studies, which included a total of 24 distinct digital interventions targeting general aggression ($N=9$), bullying and/or cyberbullying ($N=11$), and violence in intimate partner relationships ($N=4$). These interventions, encompassing interactive games, online activities, and video training, have shown promising potential in preventing youth violence by targeting essential skills such as conflict resolution, emotion regulation, knowledge and awareness, empathy, and self-efficacy. Key areas for the improvement of digital interventions in youth violence prevention involve conducting careful evaluations, refining strategies, and considering cultural factors during intervention design. Also, efforts must be prioritized to ensure their longevity and sustained accessibility.

Keywords Technology-based interventions · Youth violence · Bullying · Cyberbullying · Intimate partner violence

Introduction

Many young people around the world engage in violent behaviors, including crimes such as robbery and assault, as well as aggressive behaviors like hitting, bullying, biting, and throwing objects at others (e.g., Gottfredson & Bauer, 2007). Despite the high prevalence of youth violence, there exists a significant research gap when it comes to understanding effective strategies for its prevention. This gap is particularly evident in the realm of technology-based approaches (or digital interventions), where the evidence base supporting their effectiveness for youth violence prevention lacks a cohesive and comprehensive overview. Due to the fragmented and scattered nature of the available evidence, researchers and practitioners are impeded in their efforts to identify the common key components, features, and mechanisms that contribute to successful interventions and that might be applicable across different contexts. As a result, the advancement of the field of digital interventions against youth violence is hindered. This study aims to overcome this limitation by consolidating and synthesizing the existing strategies for preventing different forms of youth violence through technology. Its primary goal is to provide a clearer understanding of the current landscape and the emerging trends in this field. Additionally, the study aims to identify research gaps that require attention and methodologies that need improvement, and shed light on the effectiveness of these strategies in addressing youth violence.

The World Report on Violence and Health (Krug et al., 2002) identifies youth violence as occurring among individuals aged between 10 and 29 years, but the patterns of youth

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✉ Mirella Dragone
m.dragone@unifortunato.eu

[1] Department of Humanistic Studies, University of Naples "Federico II", Naples, Italy

[2] Faculty of Law, Giustino Fortunato University, Benevento, Italy

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violence can emerge in the early stages of childhood. In incidents of violence perpetrated by youth, it is common for the individuals involved to be unrelated and may have never met before. Also, in comparison to interpersonal violence among older individuals, youth violence has a greater tendency to occur in public places, such as streets and schools (Mercy et al., 2002).

This study specifically focuses on the developmental stages from childhood to adolescence, during which individuals experience significant physical, cognitive, and social changes. These phases play a crucial role in shaping individuals' behaviors and attitudes, including their potential involvement in violence.

Notably, adolescence is a period marked by a recognized tendency for an increase in violent behavior, that tendentially declines during the late adolescent years. Although this increase can be considered a transient phenomenon (Cauffman et al., 2017), it should not be underestimated. Firstly, while some instances of violent behavior during adolescence may be isolated incidents, for many young people, such behavior can become a pattern that persists into adulthood (Cauffman et al., 2017). Failing to address this pattern of violent behavior has serious and long-lasting consequences for both the individual and society as a whole. Secondly, even if violent behavior is truly transient, it can still have serious consequences in the short term. Violent behavior can result in physical harm to oneself (e.g., Van Wyk, 2022), and can lead to legal consequences, such as arrest and imprisonment (Loeber & Farrington, 2000). Notably, it can have behavioral, emotional, and psychological effects on those involved both as a victim and as a witness, including trauma, fear, and anxiety (Thompson et al., 2020), or, perhaps as a result of a desensitization effect (Huesmann & Kirwil, 2007), increase of normative beliefs about violence (e.g., Esposito et al., 2020) and engagement in peer-related aggression (e.g., Dragone et al., 2019).

Drawing on the ecological systems approach (Bronfenbrenner, 1979), developmental theories of youth violent behavior have stressed the importance of the interaction between cognitive functioning (e.g., low inhibitory control), socio-emotional and moral development (e.g., difficulties in emotion regulation, empathy), and social experiences (e.g., exposure to violence, peer pressure) in determining violent behavior (Eisner & Malti, 2015). Evidence from prospective longitudinal studies supporting the significance of these factors has been synthesized in several prior narrative and meta-analytic reviews (e.g., Bushman et al., 2016; Farrington et al., 2017; Zych et al., 2015).

Over the last few decades, there has been a significant increase in the development of violence prevention programs. As a result, many research studies have been conducted to evaluate their effectiveness in preventing general aggression (Farrington et al., 2017; Kovalenko et al., 2020), bullying (Gaffney et al., 2019), bullying and cyberbullying (Ng et al., 2022), and intimate partner violence (Hielscher et al., 2021). Overall, the available evidence suggests that violence prevention programs are generally successful in preventing aggression, delinquency, and violence in children and youth, regardless of whether they are individually focused (such as child skills training programs), family-based, or school-based (Farrington et al., 2017). However, the results seem to indicate that these programs lead to more improvements in knowledge and attitudes than in effective behavior (Kovalenko et al., 2020). Additionally, while there are many programs available, it remains unclear how specific program contents enhance their effectiveness (Kovalenko et al., 2020; Ng et al., 2022).

In recent years, technology has emerged as a promising tool for knowledge acquisition, skill enhancement, and behavior change in adolescence (Boyle et al., 2016). Advancements in technology have opened up novel possibilities to engage and educate young individuals in violence prevention through interactive and innovative approaches. This is particularly important given that contemporary youth, as digital natives (Prensky, 2001), are intimately familiar with technology and use it effortlessly in their daily routines. Interventions based on technology, such as online activities, video games, mobile applications, and virtual reality, can provide more realistic and immersive learning experiences that can help develop new skills and strategies for violence prevention (Nocentini et al., 2015).

While several systematic reviews and meta-analyses have been conducted to synthesize technology-based interventions and evidence of their effectiveness, these have mainly focused on a single problem or violence manifestation, such as intimate partner violence (Andrade et al., 2022) or bullying and cyberbullying (Calvo-Morata et al., 2020; Chen et al., 2022). Within this context, the findings derived from research on bullying and cyberbullying, particularly, warrant special attention to advance the field of violence prevention among youth. In a review conducted in 2022, it was found that technology-based approaches hold great promise in reducing involvement in these types of violence among younger age groups (Chen et al., 2022). However, similar to face-to-face interventions, the effects of technology-based interventions appear to be small for secondary school students. Specifically, it has been suggested that the limited effectiveness of anti-bullying interventions during adolescence may be due to changes in the underlying causes of the problematic behavior (Yeager et al., 2015), which are related to the unique developmental challenges of this stage of life (Swearer et al., 2016). Adolescence is a critical time window of brain plasticity, and different regions of the brain are still maturing during this period and until the early 20 s (Steinberg, 2008). Specifically, the prefrontal cortex (responsible for cognitive control) develops more slowly than the limbic

system (responsible for emotion), resulting in an imbalance that can lead to impulsive and emotionally-driven decision-making, particularly in emotionally-charged situations. Additionally, adolescents are more attuned to their social group, have heightened reward sensitivity, and are prone to sensation-seeking, which can make them more likely to engage in risky and violent behavior, even when they are aware of the negative consequences for themselves and others (Steinberg, 2008). Other interesting insights come from previous qualitative findings highlighting how the perception of bullying differs between children in primary schools and youth in middle and high schools (Guerra et al., 2011). In these older age groups, bullying is not only seen as fun but also as a form of entertainment. They actively participate in or enjoy observing fights at school and getting involved in internet dramas because it generates excitement. Also, the study found that bullying during adolescence is closely tied to popularity and sexual dynamics. Boys often use physical force to assert dominance and elevate their desirability as potential mates. Girls, on the other hand, employ bullying tactics to enhance their physical and sexual appeal, limiting competition through rumors, gossip, and exclusion. Overall, these developmental changes may translate into changes in the efficacy of behavior-change techniques that are used, which may be contributing to the decline in effectiveness of antibullying programs during later adolescence (Yeager et al., 2015). Additionally, as adolescents navigate their social and sexual development, the accompanying changes might make bullying take on new dimensions that align more with different types of violence. This would be consistent with the evidence that multiple forms of violence often come to overlap during adolescence.

Recognizing commonalities, benefits and drawbacks in interventions addressing different forms of violence might lead to a deeper understanding of the underlying factors and potentially facilitate the development of comprehensive preventive interventions. These interventions can address common risk factors and promote common protective factors, thereby potentially preventing multiple forms of violence from occurring.

Current Study

In light of the fragmented nature of research available on effective technology-based strategies for preventing youth violence, this systematic review aims to gather and analyze information on technology-based programs (i.e., set of coordinated activities), interventions (i.e., specific action or strategy), or standalone tools (i.e., specific tools or applications) currently available for preventing and addressing youth violence. By adopting a comprehensive approach, this review intends to provide a framework for better understanding the current state of research on technology-based approaches for youth violence prevention, which includes examining the specific forms of youth violence addressed, their intervention prevention levels (i.e., universal prevention, targeting all youth; indicated prevention, targeting youth at risk for violence; or selected prevention, targeting youth who have already engaged in violent behavior), types (e.g., integrated into school- or family-based programs, or community-based youth empowerment programs) and mechanics (e.g., interactive games, virtual simulations, educational videos), the populations being targeted, the mechanisms of change being addressed (i.e., targeted skills), and the specific outcomes being measured as indicators of their effectiveness.

Methods

The review procedure was based on guidelines from the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; Page et al., 2021). The systematic review protocol was registered with PROSPERO (registration number: CRD42022384699).

Search Strategy

A comprehensive literature search was initially run on 4 July 2022 and then rerun on 19 December 2022. As part of the search strategy development process, four thematic domains were firstly identified: Technology (related to the type of technology used in the intervention, e.g., mobile apps, virtual reality, gaming, or computer-based programs), intervention type (related to the type of intervention, e.g., prevention, treatment, or program), problem behavior (related to the phenomenon addressed by the intervention, e.g., aggression, bullying, delinquency, violence, or peer pressure), and population (related to the population targeted by the intervention, e.g., adolescents, youth, students, or children). It is worth noting that for the technology domain, the focus was specifically on digital interventions that were designed to educate, inform or modify behavior. Other types of digital interventions, such as those using forums, which are primarily intended for emotional support, knowledge exchange, experience-sharing, and social interaction purposes, were excluded.

Search terms were developed by examining relevant studies, including Alsem et al. (2021), Boduszek et al. (2019), DeSmet et al. (2018), and Ingram et al. (2019). To validate the search strategy and ensure that it was effective in identifying the desired articles, it was tested against two additional studies (Bosworth et al., 1998; Watson et al., 2010) that were included in a relevant systematic review (Nocentini et al.,

2015). This process helped in refining the search terms. The final search terms included the following:

Technology: "digital," "online," "computer-based," "gaming, " "internet-based," "virtual reality", "immersive environment", "immersive digital environment", "serious game", "game experience," "game-based";

Intervention type: "interven*," "program,"prevent*, "treat*";

Problem behavior: "Aggress*," "antisocial behavior," "deviant behavior," "delinquency," "violence," "peer pressure," "gang pressure," "gang violence," "youth violence," "youth aggression," "school violence," "bullying," "cyberbullying," "dating violence," "school-related violence";

Population: "adolescen*," "youth" "student*," "child*".

The following databases were searched: EBSCOhost (including APA PsycArticles, APA PsycInfo, Applied Science, Technology Source, CINAHL Complete, Criminal Justice Abstracts with Full Text, MEDLINE, MEDLINE Complete, Psychology and Behavioral Sciences Collection), Pubmed, Web of Science, Scopus, and Cochrane. The search was limited to titles, abstracts, and keywords.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for this study were carefully established to ensure the selection of high-quality and relevant evidence. The strategy employed was focused on identifying empirical studies that were written in English and published in peer-reviewed journals. No restriction based on publication date was applied. Further in detail, the review included all articles referring to (1) digital interventions aimed at reducing any manifestation of youth violence, including bullying, cyberbullying, and dating violence. The term "digital" was intended as including any kind of tool (e.g., games, apps, websites, video clips) that has been specifically created for prevention or targeted actions aimed to reduce youth involvement in violent episodes; (2) digital interventions targeting any level of prevention (universal, selective, and indicated) (Gordon, 1983), and which might be part of (larger) intervention programs (school-based, family, community, or online) or intended as standalone tools; (3) digital interventions that were tested for their impact on expected quantitative outcomes using pre-and post-test assessments. More in detail, a broad search strategy that included randomized controlled trials, non-randomized controlled trials like quasi-experimental studies, and observational studies was adopted. Although randomized controlled trials are considered the most reliable way to evaluate the effectiveness of interventions, they may not always be available, especially for complex interventions that involve rapid technological advancements. Hence, considering a variety of study designs becomes essential. Including studies with different quantitative study designs provided valuable insights into the practicality, acceptance, and real-world implementation of digital interventions.

The review included studies targeting boys and girls primarily aged between 7 and 18 years and representing different population groups. These groups included youth from the general population, those residing in correctional facilities for minors or living in residential communities, as well as those classified as juvenile offenders. This age range was included to encompass most of the school years and gain a comprehensive understanding of the diverse forms of violence that children and adolescents may exhibit throughout this developmental period. By considering the unique developmental stages that children and adolescents go through, a better understanding can be gained of how prevention interventions may be effective at different ages. Additionally, focusing on the age range of 7–18 enables the identification and evaluation of prevention strategies that can potentially mitigate the long-term consequences of youth violence and contribute to positive developmental pathways into adulthood. Finally, examining a broad age range may help us identify gaps in the existing literature on youth violence prevention, which could inform future research and the development of interventions to prevent violence.

The review excluded all the articles describing digital interventions (a) with no explicit aim to prevent youth engagement in violence, (b) which did not include pre- and post-test assessment, (c) based on clinical samples where aggression is secondary to other disorders (e.g., neurodevelopmental disorders, substance-related disorders, alcohol-related disorders, intellectual disability).

Screening and Coding

Screening of search results was conducted in two steps. In the first step, titles and abstracts were reviewed based on the criteria that were preliminarily defined. After removing duplicates, the search results were imported into Rayyan (Ouzzani et al., 2016) for initial screening. The eligibility of the articles was evaluated independently by two reviewers. Any disagreements were resolved by consulting a third reviewer. Articles that passed the initial screening were retrieved in full text. As a second step, an Excel spreadsheet was created to collect important information from the selected primary studies. Two reviewers independently coded all the included studies at the same time. As in the first step, a third reviewer was consulted to resolve any disagreements.

Methodological Quality

The methodological quality of the included studies was appraised using the Mixed Methods Appraisal Tool (MMAT;

Hong et al., 2019), a quality assessment tool or risk of bias tool designed to evaluate each study's methodology against five criteria, with specific criteria differing between study designs.

Results

The initial database search yielded a total of 1,667 documents (1,506 in the first search; 161 in the second search), of which 604 duplicates were removed. Of the remaining 1,063 articles, 266 were excluded because they did not fulfill the inclusion/exclusion criteria of publication language and type (e.g., conference proceedings, study protocols, dissertations, books, book chapters, systematic reviews, and meta-analyses). The remaining 797 records were screened based on title and abstract, resulting in the exclusion of 753 articles that were deemed non-empirical or qualitative studies, lacking intervention components or lacking virtual or technology-based components in the intervention, or focused on topics (e.g., obesity, alcohol abuse) or target populations (parents, teachers, victims of peer violence, young adults) that did not meet the inclusion/exclusion criteria. The inter-rater assessment was performed to check the decision of the inclusion/exclusion criteria. The results revealed a 99.3% agreement rate, with a Cohen's *K* of 0.93, indicating a nearly perfect agreement. Five discrepancies were identified, but they were resolved through discussions with a third reviewer until a consensus was reached.

After this screening, 44 full-text articles were assessed for eligibility. Of these, 18 were ultimately excluded. Eleven of these articles did not include any digital component; three did not evaluate the effectiveness of the intervention based on pre-and post-test assessments; one was based on a clinical sample of children with neurodevelopmental disorders; one used a sample of young adults over 18; and one was not empirical. Additionally, one article could not be retrieved in full text. In summary, the systematic review included a total of 26 articles that fully met the inclusion criteria and were analyzed in the review (Fig. 1).

Risk of Bias Within Studies

The ratings of the quality of studies included is reported in Table 1. In general, studies varied in quality, with non-randomized controlled trials and observational studies meeting a higher percentage of quality criteria on average (93.3% and 92.5%, respectively) compared to randomized controlled trials (53.3%). In randomized controlled trials, the criterion that received the highest risk of bias rating was related to the randomization process of the sample. Only one study (Valenzuela et al., 2022) accurately described the generation process of randomization. The criterion that was most commonly rated as unclear was related to outcome assessor blinding, as it was not evident in any of these studies. As regards the other studies, the criterion that received the most concern rating pertained to the representativeness of the target population. The utilization of non-probabilistic samples was a common practice among the studies included in the review. However, most of these studies did not conduct any analyses to assess the representativeness of the target sample, which may have limited the generalizability of their findings.

To access more detailed information about article screening and risk of bias evaluation, please refer to the supplemental materials available on the Open Science Framework (https://osf.io/vxqhb/?view_only=5d7faa06858d49fc88f15a450ae67c04).

General Characteristics

Table 1 provides a summary of the general characteristics and intervention design for each study included in the review. The studies were published between 1998 and 2022, with a notable increase in the number of studies published between 2017 and 2022 (n = 19). They were conducted in various countries, with a significant proportion taking place in the United States (n = 9; 34%). Two studies, which reported on the same digital intervention (Kolić-Vehovec et al., 2019; Rončević Zubković et al., 2022) were conducted in Spain, the UK, Ireland, and Malta. One study was conducted in both the UK and Germany (Watson et al., 2010). Other studies were conducted in the Netherlands (Alsem et al., 2021), Spain (Barreda-Ángeles et al., 2021; Garaigordobil & Martínez-Valderrey, 2018), Belgium (DeSmet et al., 2018), Portugal (Ferreira et al., 2021), Finland (Kärnä et al., 2011), Colombia (Gonzalez et al., 2022), Canada (Baldwin et al., 2010; Rubin-Vaughan et al., 2011), Barbados (Boduszek et al., 2019), Chile (Valenzuela et al., 2022), China (Gu et al., 2022), Japan (Nagamatsu et al., 2021), and Singapore (Ong et al., 2019).

Collectively, the 26 studies analyzed in the review made reference to 24 distinct digital interventions. For a detailed description of the interventions, please refer to Supplementary materials.

In terms of the targeted problem behaviors, the interventions can be categorized as follows: nine interventions focused on general aggression (Alsem et al., 2021; Baldwin et al., 2010; Bosworth et al., 1998, 2000; Jouriles et al., 2019; Lochman et al., 2017; Ong et al., 2019; Oscos-Sanchez et al., 2021; Roche et al., 2022), seven interventions targeted bullying (Barreda-Ángeles et al., 2021; Gu et al., 2022; Kärnä et al., 2011; Kolić-Vehovec et al., 2019; Rončević Zubković et al., 2022; Rubin-Vaughan et al., 2011; Sanchez et al., 2017; Watson et al., 2010), two interventions addressed both bullying and cyberbullying (Garaigordobil

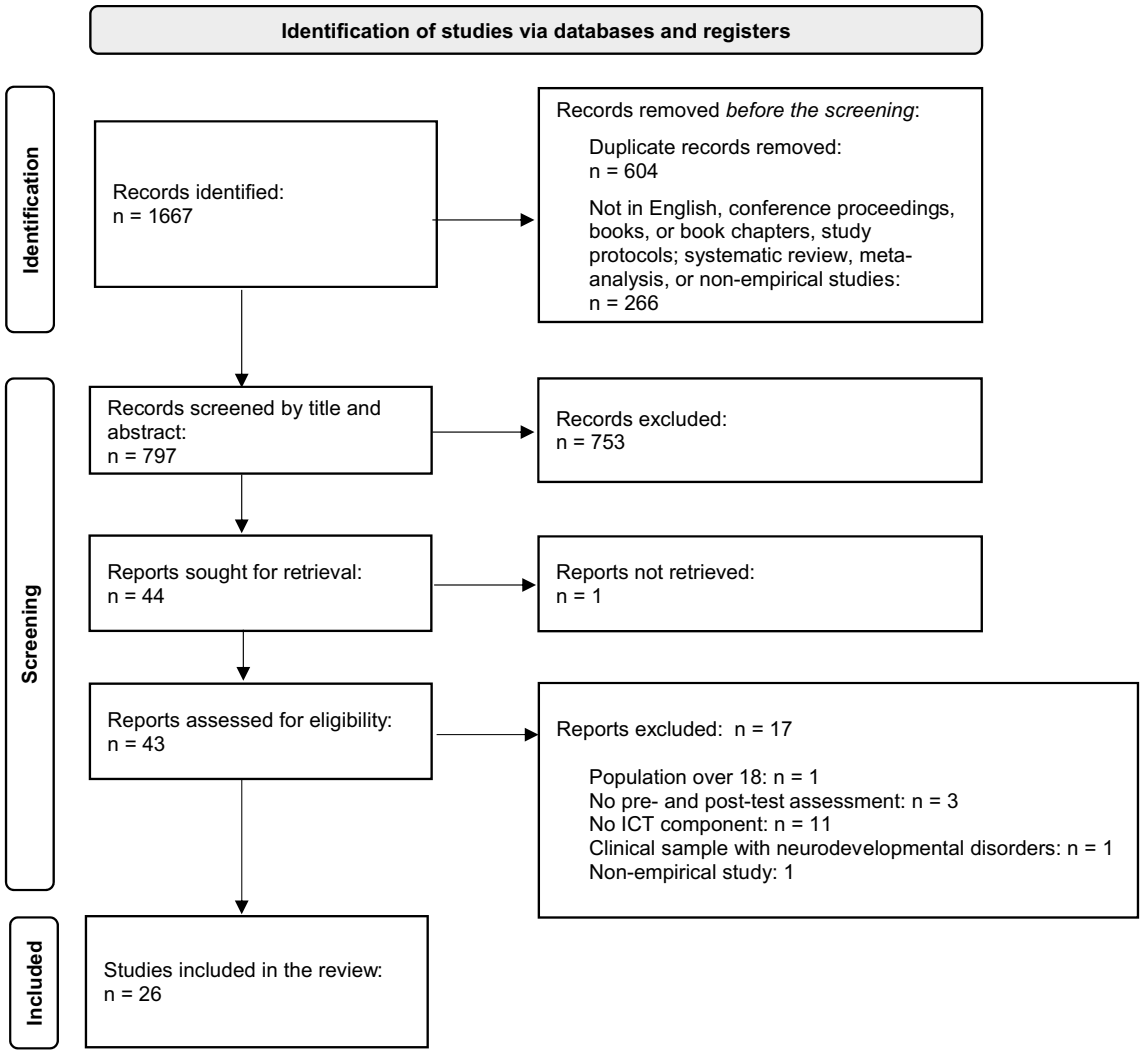

Fig. 1 PRISMA flow diagram

& Martínez-Valderrey, 2018; Ingram et al., 2019), two interventions focused solely on cyberbullying (DeSmet et al., 2018; Ferreira et al., 2021), and four interventions targeted violence in intimate partner relationships (Boduszek et al., 2019; Gonzalez et al., 2022; Nagamatsu et al., 2021; Peskin et al., 2014).

Most of the studies included in this review were conducted in educational settings. Specifically, there were six studies involving children in elementary schools (Barreda-Ángeles et al., 2021; Lochman et al., 2017; Rubin-Vaughan et al., 2011; Sanchez et al., 2017; Valenzuela et al., 2022; Watson et al., 2010), seven in middle schools (Bosworth et al., 1998; Bosworth et al., 2000; DeSmet et al., 2018; Ingram et al., 2019; Kolić-Vehovec et al., 2019; Peskin et al., 2014; Rončević Zubković et al., 2022), four in high schools (Ferreira et al., 2021; Garaigordobil & Martínez-Valderrey, 2018; Jouriles et al., 2019; Nagamatsu et al., 2021), one in elementary, middle and high schools (Boduszek et al., 2019), two in both elementary and middle schools (Baldwin et al., 2010; Kärnä et al., 2011), and two in both middle and high schools (Gonzalez et al., 2022; Gu et al., 2022). Additionally, one study focused on two community-based programs for adolescents and young adults aged 10–23 years (Oscos-Sanchez et al., 2021), one reported on a standalone tool for children and pre-adolescents (6–12 years; Ong et al., 2019), and two described interventions in primary care for children (8–12 years; Alsem et al., 2021) and adolescents (14–18 years; Roche et al., 2022). Regarding prevention level, four digital interventions were categorized as indicated (Alsem et al., 2021; Lochman et al., 2017; Roche et al., 2022; Sanchez et al., 2017), two were classified as both indicated and universal (Kärnä et al., 2011; Ong et al., 2019; Valenzuela et al., 2022), while the remaining were categorized as universal digital interventions.

The digital intervention delivery platforms varied among the studies included in the review. Specifically,

Table 1 Characteristics of the studies included in the systematic review

Authors/Year	Name (if provided)	Country	Target	Type of youth violence	Targeted skills/abilities	Level of prevention and setting	Delivery platform	Format	MMAT rating (percentage of quality criteria met)
Alsem et al. (2021)	YourSkills	The Netherlands	8–12 yo	General aggression	Anger management	Indicated; Primary care	Virtual reality	Game	80
Baldwin et al. (2010)		Canada	Elementary and middle school (9–15 yo)	General aggression	Social connection and self-acceptance	Universal; School-based	Computer-based	Game-like activities	60
Barreda-Ángeles et al. (2021)		Spain	Elementary school (10–12 yo)	Bullying	Empathy for the victim in bullying situations	Universal; School-based	Virtual reality Headset	Scenarios	100
Boduszek et al. (2019)	Jesse	Barbados	Elementary, middle, and high school (9–17 yo)	Violence in intimate relationships	Affective and cognitive responsiveness towards victims; prosocial behavior and thoughts	Universal; School-based	Computer-based	Game	40
Bosworth et al. (1998)	SMART talk	The US	Middle school (grades 6–8)	General aggression	Anger management; perspective-taking; dispute resolution	Universal; School-based	Computer-based	Game-like activities	100
Bosworth et al. (2000)	SMART talk	The US	Middle school (grades 6–8)	General aggression	Anger management; perspective-taking; dispute resolution	Universal; School-based	Computer-based	Game-like activities	60
DeSmet et al. (2018)	Friendly attac	Belgium	Middle school (13–14 yo)	Cyberbullying	Self-efficacy; pro-social skills; intention to act as a positive bystander	Universal; School-based	Computer-based	Game	60
Ferreira et al. (2021)	Com@Viver	Portugal	High school (grades 7–8)	Cyberbullying	Affective and cognitive empathy	Universal; School-based	Computer-based	Game	40
Garaigordobil and Martínez-Valderrey (2018)	Cooperative Cybereduca 2.0	Spain	High school (grades 9–10)	Bullying and cyberbullying	Knowledge; coping strategies	Universal; School-based	Computer-based and face-to-face components	Game	40
Gonzalez et al. (2022)	Tsiunas	Colombia	Middle and high school (grades 8–10)	Violence in intimate relationships	Pro-violence attitudes and thoughts	Universal; School-based	Computer and mobile apps	Game	100

Table 1 (continued)

Authors/Year	Name (if provided)	Country	Target	Type of youth violence	Targeted skills/abilities	Level of prevention and setting	Delivery platform	Format	MMAT rating (percentage of quality criteria met)
Gu et al. (2022)		China	Middle and high school (13–18 yo)	Bullying	Empathy and willingness to engage in supportive behaviors; opinions about bullying; commitment to stopping bullying others in the future	Universal; School-based	Virtual reality	Game	40
Ingram et al. (2019)	Stand up	The US	Middle school (grades 7–8)	Bullying and cyberbullying	Understanding the consequences of common ineffective responses to bullying, and how to make a difference with small and realistic actions	Universal; School-based	Virtual reality	Scenarios	100
Jouriles et al. (2019)	TakeCARE	The US	High school (14–19 yo)	General aggression	Self-efficacy for intervening	Universal; School-based	Internet-based	Videoclips	60
Kärnä et al. (2011)	KiVa	Finland	Elementary and middle school (grades 4–6)	Bullying	Knowledge about bullying and social skills to act in appropriate ways in bullying situations	Universal and indicated; School-based	Computer-based and face-to-face components	Game-like activities	60
Kolić-Vehovec et al. (2019)	Econfidence—school of empathy	Spain, the UK, Ireland, Malta	Middle school (12–14 yo)	Bullying	Knowledge about the identification of bullying situations, appropriate reactions (aggressive, passive, and assertive reactions)	Universal; School-based	Computer-based	Game	40

Table 1 (continued)

Authors/Year	Name (if provided)	Country	Target	Type of youth violence	Targeted skills/abilities	Level of prevention and setting	Delivery platform	Format	MMAT rating (percentage of quality criteria met)
Lochman et al. (2017)	CP-IE: coping power—internet enhanced	The US	Elementary school (grade 5)	General aggression	Social problem-solving, goal-setting and emotional regulation skills	Indicated; School-based	Internet-based and face-to-face components	Game-like activities and videoclips	60
Nagamatsu et al. (2021)		Japan	High school and college (age < 20 years)	Violence in intimate relationships	Pro-violence attitudes, healthy conflict resolution (empathy; assertiveness; attack avoidance)	Universal; School-based	Video programs and internet-based	Video teaching	100
Ong et al. (2019)	RegnaTales	Singapore	Children and adolescents (6–12 yo)	General aggression	Emotion regulation, anger management, communication and problem-solving, perspective taking, use of cognitive restructuring techniques	Universal and indicated; Standalone tool	Mobile Apps	Game	80
Oscos-Sanchez et al. (2021)	"Violence Prevention Program" and "Positive Youth Development Program"	The US	Adolescents and young adults (10–23 yo)	General aggression	Creative thinking to solve difficult situations and self-expression	Universal; Community-based	Internet-based	Activities	40
Peskin et al. (2014)	It's Your Game... Keep It Real Program	The US	Middle school	Violence in intimate relationships	Knowledge, skills-training for evaluating relationships, peer pressure, and social support, setting personal limits and respecting others' limits, and recognizing peer norms	Universal; School-based	Computer-based and face-to-face components	Game-like activities and videoclips	60

Table 1 (continued)

Authors/Year	Name (if provided)	Country	Target	Type of youth violence	Targeted skills/abilities	Level of prevention and setting	Delivery platform	Format	MMAT rating (percentage of quality criteria met)
Roche et al. (2022)	SafERteens	The US	Adolescents (14–18 yo)	General aggression	Motivation to change, self-efficacy, development of a discrepancy between current behavior and future goals/values, rolling with resistance, and increasing problem recognition	Indicated; Primary care	Internet-based	Videoclips	100
Rončević Zubković et al. (2022)	Econfidence—School of empathy	Spain, the UK, Ireland, Malta	Middle school (12–14 yo)	Bullying	Knowledge about the identification of bullying situations, appropriate reactions, and compassion	Universal; School-based	Computer-based	Game	80
Rubin-Vaughan et al. (2011)	Quest for the Golden Rule	Canada	Elementary school (grades 2–5)	Bullying	Attitudes about fairness and social justice, and about bullying and coping strategies; attitudes and knowledge about respectful treatment of friends and peers, and strategy to stay safe from bullying; knowledge about strategies to face bullying situations	Universal; School-based	Computer-based	Game	100

Table 1 (continued)

Authors/Year	Name (if provided)	Country	Target	Type of youth violence	Targeted skills/abilities	Level of prevention and setting	Delivery platform	Format	MMAT rating (percentage of quality criteria met)
Sanchez et al. (2017)	Adventures aboard the S.S. Green	The US	Elementary school (grades 3–5)	Bullying	Respect, consequences, responsibility, impulse control, communication, perspective-taking, friendship skills, social initiation, cooperation, compromise, emotion regulation	Indicated; School-based	Computer-based	Game	60
Valenzuela et al. (2022)		Chile	Elementary school (grades 5–6)	Bullying	Knowledge about bullying and social skills to act in appropriate ways in bullying situations	Universal and indicated; School-based	Computer-based and face-to-face components	Game-like activities	80
Watson et al. (2010)	FearNot!	The UK and Germany	Elementary school (7–11 yo)	Bullying	Knowledge about bullying and respective coping strategy	Universal; School-based	Computer-based	Game	80

twelve interventions used computer-based platforms, five were based on the internet, four utilized virtual reality or immersive formats, one used mobile apps, and one was a multiplatform tool (computer-based and mobile app). Four interventions also had face-to-face components (Garaigordobil & Martínez-Valderrey, 2018; Kärnä et al., 2011; Lochman et al., 2017; Peskin et al., 2014; Valenzuela et al., 2022), whereas two others included a final youth summit with in-person attendance (Oscos-Sanchez et al., 2021). Additionally, most of the interventions included in the review were designed as interactive video games (n = 12) running on computers (e.g., DeSmet et al., 2018) or virtual reality systems (e.g., Alsem et al., 2021). Games incorporate realistic scenarios, role-playing, decision-making, problem-solving, and feedback mechanisms to engage the user and reinforce positive behaviors. Two of the included interventions used virtual reality or immersive formats to generate environments that simulate realistic social situations where young people can learn how to navigate conflicts and challenging interactions without resorting to violence (Barreda-Ángeles et al., 2021; Ingram et al., 2019). Three interventions primarily used educational videos to provide young people with knowledge and skills to make informed and responsible decisions about how to interact with others in a peaceful and respectful manner and promote a culture of non-violence in their communities (Jouriles et al., 2019; Nagamatsu et al., 2021; Roche et al., 2022). Three interventions used the internet to provide games and activities such as the presentation of dilemmas, quizzes, tournaments, and opinion polls (Lochman et al., 2017; Oscos-Sanchez et al., 2021). Lastly, one intervention used a conditioning approach with a computer-like game task where the player clicked on words and names appearing in different quadrants on the screen (Baldwin et al., 2010).

Notably, of the 24 tools evaluated in this study, four were freely accessible as of the date of last access (2nd March 2023) (Boduszek et al., 2019; Garaigordobil & Martínez-Valderrey, 2018; Ong et al., 2019; Watson et al., 2010), while two provided only limited access (Peskin et al., 2014; Sanchez et al., 2017). The remaining 20 tools either were not freely accessible or lacked information regarding their accessibility.

Targeted Skills

In the analysis of the digital interventions reviewed, five primary areas of skill development were identified: Conflict resolution skills, emotion regulation, knowledge and awareness, empathy and prosocial skills, and self-efficacy. Interventions targeting conflict resolution skills (e.g., Lochman et al., 2017) aim to teach problem-solving, communication, perspective-taking, and other-oriented attitudes to help youth navigate difficult social situations and reduce the likelihood of aggressive or violent behavior. Interventions targeting emotion regulation skills (e.g., Alsem et al., 2021; Bosworth et al., 2000) commonly focus on anger management and cognitive restructuring techniques to help youth manage their emotions and reduce impulsive or aggressive behavior. Many interventions focus on increasing knowledge and awareness about various forms of violence, including bullying, cyberbullying, and intimate partner violence (e.g., Kolić-Vehovec et al., 2019; Valenzuela et al., 2022). This includes understanding the consequences of violence, identifying the signs of violence, and learning strategies for coping with or preventing violence. Interventions focused on empathy and prosocial skills emphasize the importance of showing concern towards victims of violence, intervening in violent situations, and developing healthy relationships with peers and romantic partners (e.g., Barreda-Ángeles et al., 2021; Boduszek et al., 2019; Ferreira et al., 2021). Lastly, self-efficacy skills (e.g., DeSmet et al., 2018; Jouriles et al., 2019), as framed within the social cognitive perspective (Bandura, 1986), build confidence by emphasizing choice and responsibility, increasing problem recognition, motivation, and self-efficacy for change.

Evidence of Effectiveness

Table 2 provides an overview of the results obtained from the evaluations conducted for each of the reviewed studies. As can be observed, most studies were randomized controlled trials (n = 15), with 10 using pre-and post-test assessments and five using pre-, post-, and follow-up designs. Three studies comprised a control group but did not use random assignment to the experimental and control condition (Ingram et al., 2019; Roche et al., 2022; Watson et al., 2010). Eight studies were based on pre-and post-test assessments but did not include a control group (Alsem et al., 2021; Barreda-Ángeles et al., 2021; Bosworth et al., 1998; Gonzalez et al., 2022; Nagamatsu et al., 2021; Ong et al., 2019; Rončević Zubković et al., 2022; Rubin-Vaughan et al., 2011).

The evaluation studies for general aggression provide general evidence for the effectiveness of digital games and game-like activities in preventing engagement in aggressive behaviors in both children (e.g., Alsem et al., 2021; Lochman et al., 2017; Ong et al., 2019) and adolescents (e.g., Bosworth et al., 2000; Roche et al., 2022). Also the video-based training, which was used in the TakeCARE intervention (Jouriles et al., 2019), resulted to be effective in increasing positive bystander behavior among high school students, with self-efficacy partially mediating the effect of the program on observed bystander behavior. Lastly, community-based participatory action research programs targeting violence prevention delivered through internet-based platforms were found to effectively reduce violence outside of school

and within the school setting, depending on the specific risk or protective factors targeted by the intervention (Oscos-Sanchez et al., 2021).

The findings from interventions targeting bullying produced mixed findings. The game "Adventures aboard the S.S. GRIN," which was an indicated intervention, for instance, did not result in a significant decrease in bullying perpetration (Sanchez et al., 2017). Similarly, Fear not! (Watson et al., 2010), which was tested in Germany and the UK, was found to be ineffective at increasing children's coping strategy knowledge to handle bullying situations. Research on the School of Empathy game has produced conflicting results. One study found that playing the game improved participants' knowledge of appropriate behavior and increased their empathic concern (Rončević Zubković et al., 2022). However, another study conducted to evaluate the effects of playing the same game reported that all students, including those who played the game, exhibited even more aggressive behavior and less assertiveness (Kolić-Vehovec et al., 2019). The authors of the latter study attributed this effect to a potential bias related to the assessment tool they used to classify aggressive reactions. Therefore, further studies are needed to clarify the origin of this unexpected outcome.

The game for primary school children incorporated into the KiVa Program was found to be a promising intervention in Finland, with one study showing a significant reduction in self-reported bullying perpetration, increased defender behavior, antibullying attitudes, and empathy (Kärnä et al., 2011). However, a study in the Chilean context found that the digital component did not enhance the program's effectiveness (Valenzuela et al., 2022), perhaps because of the different cultural context. Still, the game-based Quest for the Golden Rule program (Rubin-Vaughan et al., 2011) was found to be effective in improving knowledge and attitudes across all the program's modules, with significant improvements observed in social skills, coping strategies, and strategies to refuse and cope with bullying. The Cooperative Cybereduca 2.0 program (Garaigordobil & Martínez-Valderrey, 2018) appeared to be effective at reducing bullying and cyberbullying, and increasing positive social behaviors, self-esteem, cooperative conflict resolution strategies, and empathy skills among adolescents. Finally, the Friendly ATTAC game (DeSmet et al., 2018) was found to be associated with significant improvements in self-efficacy, prosocial skills, and the intention to act as a proactive bystander. As for the interventions using virtual reality or immersive formats, the reviewed studies indicated that the Stand Up intervention (Ingram et al., 2019) yielded positive outcomes by increasing empathy, fostering a sense of school belonging, promoting willingness to intervene as an active bystander, and reducing instances of traditional bullying. However, its effectiveness in addressing cyberbullying or relational aggression was not observed. Additionally, the 360◦-videos for school-based bullying prevention program developed by Barreda-Ángeles et al. (2021) showed that the immersive video was effective in reducing bullying perpetration and increasing defender behavior, antibullying attitudes, and empathy.

As regards the studies focused on intimate violence, the results evidenced an overall effectiveness of digital interventions in increasing affective responsiveness (Boduszek et al., 2019), altering beliefs related to patriarchal patterns and tolerance levels of violence against women for both men and women participants (Gonzalez et al., 2022), and improving attitudes towards healthy conflict resolution and reducing dangerous attitudes leading to mental, physical, and sexual violence (Nagamatsu et al., 2021). In terms of behavior change, the study evaluating the effectiveness of the intervention using "It's your game… keep it real" (Peskin et al., 2014) showed that participants in the intervention condition had significantly lower odds of emotional dating violence perpetration compared to those in the control condition. However, there was no significant difference in the odds of physical dating violence perpetration between the two groups.

Discussion

Youth violence has been a significant public health issue for decades and, despite many prevention efforts (Farrington et al., 2017), it continues to pose a serious threat to public safety. Digital interventions have emerged as a promising tool for preventing youth violence, although the evidence base supporting their effectiveness is scattered and lacks a cohesive framework. This systematic review offers a comprehensive analysis of digital interventions designed to prevent and tackle youth violence in all its manifestations. By consolidating and synthesizing the available research, the review offers valuable insights for researchers, practitioners, and policymakers by identifying commonalities that might make interventions more flexible, adaptable, and effective in addressing multiple manifestations of violence, and highlighting potential gaps and areas for future research. The literature search identified 24 digital interventions targeting different forms of youth violence. These forms include general aggression, bullying and cyberbullying, and intimate partner violence.

Target Populations

The target population for digital interventions addressing youth violence varies depending on the type of violence addressed. For aggression, the primary target population identified is middle and high school adolescents (Baldwin

Table 2 Evidence of the intervention effectiveness

Authors/Year	Type of youth violence	Main outcomes measured for effectiveness evaluation	Study design	Participants	Main findings
Alsem et al. (2021)	General aggression	Aggressive behavior (ad hoc questionnaire)	Pre- and post-tests; No control group	6 children and adolescents (8–12 years)	Parents reported decreases in children's aggression over the treatment period. No effect was found based on children's reports
Baldwin et al. (2010)	General aggression	Intention to behave aggressively in response to a provocative scenario (ad hoc vignettes)	Pre- and post-tests; RCT	138 children and adolescents (9–15 years)	Playing the game was associated with lower scores of aggressive intentions
Barreda-Ángeles et al. (2021)	Bullying	Negative arousal (self-reported questionnaire and psychophysiological responses); antibullying attitudes, empathy, defender behavior, bullying perpetration (previously published questionnaires)	Pre- and post-tests; No control group	35 children and adolescents (10–12 years)	The videos were associated with increased negative arousal, anti-bullying attitudes, empathy, and defender behavior, and reduced bullying
Boduszek et al. (2019)	Violence in intimate relationships	Affective and cognitive responsiveness toward victims (ad hoc questionnaires)	Pre-, post- and follow-up tests; RCT	172 children and adolescents (9–17 years)	Participants in the experimental condition reported a significant increase in affective responsiveness after the intervention. No significant effects were found for cognitive responsiveness

Table 2 (continued)

Authors/Year	Type of youth violence	Main outcomes measured for effectiveness evaluation	Study design	Participants	Main findings
Bosworth et al. (1998)	General aggression	Knowledge about anger management and dispute resolution. prosocial behavior, self-efficacy, intention to use nonviolent strategies, trouble behavior (ad hoc and previously published questionnaires)	Pre- and post-tests; No control group	119 adolescents (7th grade)	Participants reported an increased understanding of conflict management terms and principles, and knowledge of how certain behaviors can contribute to the escalation of a conflict situation. They also reported increased prosocial behavior and intentions to use nonviolent strategies. However, the study did not find a significant increase in students' confidence in handling conflict situations using nonviolent strategies. Finally, the program was associated with a significant decrease in the number of times students got into trouble at home, school, and in the community
Bosworth et al. (2000)	General aggression	Self-awareness, beliefs supportive of violence, self-efficacy, intentions to use nonviolent strategies, and aggressive behavior (ad hoc and previously published questionnaires)	Pre- and post-tests; RCT	516 adolescents (6th, 7th, and 8th grades)	The intervention successfully reduced students' support for violence and increased their self-awareness and intention to use nonviolent strategies. No significant results were found for self-efficacy and aggressive behavior
DeSmet et al. (2018)	Cyberbullying	Self-efficacy, pro-social skills, intention to act as a positive bystander, prevalence of bullying and cyberbullying (previously published questionnaires)	Pre-, post- and follow-up tests; RCT	216 adolescents (8th grade; 13–14 years)	Playing the game was associated with significant improvements in self-efficacy, prosocial skills, and the intention to act as a proactive bystander. No significant effect of the intervention was found on bullying and cyberbullying prevalence

Table 2 (continued)

Authors/Year	Type of youth violence	Main outcomes measured for effectiveness evaluation	Study design	Participants	Main findings
Ferreira et al. (2021)	Cyberbullying	Perspective taking (previously published questionnaire); affective empathy and empathic concern (game-based measures)	Pre- and post-tests; RCT	221 adolescents (7th and 8th grades)	Students who played the game demonstrated significantly higher levels of cognitive empathy, empathic concern, and affective empathy compared to the students who did not play the game
Garaigordobil and Martínez-Valderrey (2018)	Bullying and cyberbullying	Bullying and cyberbullying, aggressiveness, school violence, social behaviors, self-esteem, conflict management, empathy (previously published questionnaires)	Pre- and post-tests; RCT	176 adolescents (13–15 years)	The game was found to decrease face-to-face bullying and cyberbullying behaviors, as well as different types of school violence, premeditated and impulsive aggression, and the use of aggressive conflict resolution strategies. Also, significant positive associations were found with social behaviors, self-esteem, cooperative conflict resolution strategies, and empathy skills
Gonzalez et al. (2022)	Violence in intimate relationships	Recognition of gender-based violence, tolerance of violence against women, entrenchment of patriarchal male patterns, attitudes toward violence against women, and co-responsible masculinities (ad hoc questionnaires)	Pre- and post-tests; No control group	753 adolescents (12–19 years)	The use of the game had a significant effect on altering the beliefs of both men and women related to patriarchal patterns, tolerance levels of violence against women, and attitudes toward violence against women

Table 2 (continued)

Authors/Year	Type of youth violence	Main outcomes measured for effectiveness evaluation	Study design	Participants	Main findings
Gu et al. (2022)	Bullying	Empathy and willingness to engage in supportive behaviors, moral opinions about bullying, and commitment to stopping bullying others in the future (ad hoc questionnaires)	Pre- and post-tests; RCT	234 adolescents (13–18 years)	Playing in the role-exchange condition (bully-victim or victim-bully) was significantly associated with more morally correct opinions about bullying, as well as increased empathy and willingness to engage in supportive behavior. Participants in this condition also showed increased commitment to stopping bullying others. In contrast, playing only the role of the victim did not show significant improvement. Lastly, the study found that playing in the bystander condition positively affected participants' opinions on bullying and promoted supportive behavior, but it was less effective than the role-exchange paradigm
Ingram et al. (2019)	Bullying and cyberbullying	Empathy, school belonging, willingness to intervene, bullying and cyberbullying perpetration, relational aggression (previously published measures)	Pre- and post-tests; non-RCT	118 adolescents (11–14 years)	Virtual reality condition yielded increased empathy from pre-to post-intervention compared to the control condition. Through the mediating role of empathy, changes in the desired directions were also observed for traditional bullying, sense of school belonging, and willingness to intervene as an active bystander, but not for cyberbullying or relational aggression

Table 2 (continued)

Authors/Year	Type of youth violence	Main outcomes measured for effectiveness evaluation	Study design	Participants	Main findings
Jouriles et al. (2019)	General aggression	Self-efficacy for intervening, bystander behavior (previously published measures and game-based instruments)	Pre-, post- and follow-up test; RCT	165 adolescents (14–19 years)	Participants who participated in the intervention reported more bystander behavior and demonstrated greater levels of bystander behavior in simulations immediately after the intervention and at the 6-month follow-up. Self-efficacy was found to partially mediate the effect of the intervention on observed bystander behavior
Kärnä et al. (2011)	Bullying	Bullying perpetration, antibullying attitudes, empathy, self-efficacy for defending behavior, well-being at school (previously published questionnaires)	Pre-, post- and follow-up test; RCT	8,237 children and adolescents (10–12 years)	Experimental schools showed a reduction in self-reported bullying perpetration compared to control schools. Additionally, the intervention was linked to increased defender behavior, antibullying attitudes, empathy, self-efficacy for defending, and well-being at school
Kolić-Vehovec et al. (2019)	Bullying	Knowledge about the identification of bullying situations, bullying perpetration, and appropriate reactions (aggressive, passive, and assertive reactions) (previously published questionnaires)	Pre- and post-tests; RCT	355 adolescents (12–14 years)	Results indicate a weak effect of the game. Students in all groups, including those who played the experimental game, reported even more aggressive and less assertive behaviors
Lochman et al. (2017)	General aggression	Aggression and conduct problems (previously published questionnaires)	Pre- and post-tests; RCT	97 children (5th grade)	Results indicated that, compared to the control group, CP-IE children showed significantly fewer increases in conduct problem behaviors throughout the year

Table 2 (continued)

Authors/Year	Type of youth violence	Main outcomes measured for effectiveness evaluation	Study design	Participants	Main findings
Nagamatsu et al. (2021)	Violence in intimate relationships	Healthy conflict resolution, attitudes that lead to the perpetration of violence, dangerous attitudes toward sexual violence, preventive attitudes toward sexual violence (previously published questionnaires)	Pre- and post-tests; No control group	955 teenagers	The results showed a significant effect of the intervention in improving adolescents' attitudes towards healthy conflict resolution and reducing dangerous attitudes that lead to mental, physical, and sexual violence
Ong et al. (2019)	General aggression	Reactive and proactive aggression (previously published questionnaires)	Pre- and post-tests; No control group	6 children and adolescents (6–12 years)	The results indicated that children reported significantly less reactive aggression after using mobile apps
Oscos-Sanchez et al. (2021)	General aggression	Violence outside and inside the school (previously published questionnaires)	Pre-, post- and follow-up tests; RCT	606 children, adolescents, and young people (10–23 years)	The interventions had positive effects on reducing violence within the school setting and outside of the school
Peskin et al. (2014)	Violence in intimate relationships	Physical and emotional violence (previously published questionnaires)	Pre- and post-tests; RCT	766 adolescents (13 years)	The results showed that students who received the intervention had significantly lower odds of emotional dating violence perpetration than students in the control condition did, whereas the odds of physical dating violence perpetration were not significantly different between the two groups
Roche et al. (2022)	General aggression	Self-efficacy for non-violence, intention to avoid fighting, severe peer aggression (previously published questionnaires)	Pre- and post-tests; non-RCT	110 adolescents (14–18 years)	The intervention group showed significantly greater reductions in severe peer aggression and increased intention to avoid fighting
Rončević Zubković et al. (2022)	Bullying	Knowledge about the identification of bullying situations, appropriate reactions, and compassion (previously published questionnaires)	Pre- and post-tests; no control group	120 adolescents (12–14 years)	The experimental game significantly improved the participants' knowledge of appropriate behavior in response to the challenges presented in the game. Additionally, participants reported an increased level of empathic concern due to the immersive experience

Table 2 (continued)

Authors/Year	Type of youth violence	Main outcomes measured for effectiveness evaluation	Study design	Participants	Main findings
Rubin-Vaughan et al. (2011)	Bullying	Attitudes about fairness and social justice, and about bullying and coping strategies, attitudes and knowledge about respectful treatment of friends and peers, and strategy to stay safe from bullying, knowledge about strategies to face bullying situations (ad hoc questionnaires)	Pre- and post-tests; No control group	Sample sizes range from 226 to 438 depending on the tested module (2nd to 6th grades)	Significant improvements have been observed in knowledge and attitudes across all game modules. Specifically, children gained knowledge about fairness and safety issues in their schools through the Bark Academy module, social skills through the Mission to Mars module, and strategies to refuse and cope with bullying through the Ghoul School module
Sanchez et al. (2017)	Bullying	Social literacy, social self-efficacy, bullying perpetration (previously published questionnaires)	Pre- and post-tests; RCT	69 children (7–11 years)	The game effectively enhanced children's social literacy. However, the study did not observe a significant decrease in bullying perpetration in the experimental group
Valenzuela et al. (2022)	Bullying	Bullying perpetration and self-reported witnessing (previously published questionnaires)	Pre- and post-tests; RCT	1363 students (9–11 years)	The digital component did not enhance the effectiveness of the traditional intervention
Watson et al. (2010)	Bullying	Knowledge about strategies to handle bullying situations (ad hoc questionnaire)	Pre- and post-tests	908 children (7–11 years)	The intervention was not effective at increasing children's coping strategy knowledge

et al., 2010; Bosworth et al., 1998, 2000; Jouriles et al., 2019; Oscos-Sanchez et al., 2021; Roche et al., 2022). This is consistent with the fact that aggression generally tends to increase and reach its peak during pre-adolescent and adolescent years (Dodge & Pettit, 2003; Moffitt & Caspi, 2001). However, it is worth noting that the review identified two digital interventions that target younger children (ages 8–12) with aggressive behavior problems: one developed for use in primary care (Alsem et al., 2021) and the other as a standalone tool that can be accessed by children independently or with the help of an adult (such as a parent or healthcare provider) (Ong et al., 2019). These interventions are based on the idea that it is crucial to address aggressive behavior problems in childhood, as research indicates that these problems often arise during this period. Also, children with aggressive behavior problems are at a heightened risk for negative outcomes later in life, including lower educational achievement, delinquency, substance abuse, and mental health issues (Burkey et al., 2018; Loeber & Farrington, 2000).

For bullying, the target population extends also to elementary school children (Barreda-Ángeles et al., 2021; Kärnä et al., 2011; Rubin-Vaughan et al., 2011; Sanchez et al., 2017; Valenzuela et al., 2022; Watson et al., 2010), with an overall sample ranging from 7 to 18 years old. This might be because the empirical literature has indicated that bullying experiences and perpetration peak during the transitional period from late childhood to early adolescence, particularly when adolescents transition from elementary to middle school (Bellmore et al., 2016; Smith et al., 1999). Moreover, research indicates that interventions targeting bullying are less effective with high school students compared to middle school students (Yeager et al., 2015). Still, the literature has highlighted that children who engaged in bullying during elementary school were more likely to exhibit deviant behavior later in adolescence (Kumpulainen & Räsänen, 2000) and adulthood (Farrington, 1993; Olweus, 1991). Therefore, it is suggested that interventions targeting bullying start early to prevent these behaviors from becoming entrenched (Ttofi & Farrington, 2010). Conversely, digital interventions aiming at preventing cyberbullying primarily involved middle and high school students (DeSmet et al., 2018; Ferreira et al., 2021). Reviews of relevant studies (Kowalski et al., 2014; Tokunaga, 2010) have suggested that cyberbullying perpetration tends to increase with age. Additionally, it appears that involvement in cyberbullying may peak around the age of 15, which is slightly later than the peak for traditional bullying. This difference could be due to older children having more opportunities and skills in using mobile phones and the internet to engage in cyberbullying (Smith, 2015).

For intimate partner violence, the target population includes students between 12 and 19 years of age (Boduszek et al., 2019; Gonzalez et al., 2022; Nagamatsu et al., 2021; Peskin et al., 2014). This is consistent with the fact that adolescence is considered a critical period for the onset of dating violence due to the rapid developmental changes in physical, social, and psychological realms that occur during this time and that might make romantic relationships more complex (Lapierre et al., 2019). According to Espelage and Holt (2007), adolescents are still in the process of developing their identities, social and career goals, as well as their conflict management and interpersonal problem-solving skills, all while navigating emotionally charged interactions. These changes, coupled with puberty and shifting social dynamics, can result in teen dating violence when conflicts and emotions are not effectively managed within adolescent romantic relationships. Furthermore, dating violence has been found to be common during adolescence due to the elevated significance of social status and acceptance among peers. This pressure can create a need to conform to social norms and expectations, including those related to gender roles and expectations. Adolescents who do not conform to these norms may be at an increased risk of experiencing dating violence (Ellis et al., 2013).

Context of Intervention

The contexts where digital interventions are implemented can impact their effectiveness in preventing youth violence. Overall, school-based interventions are the most common context for digital interventions aimed at preventing all forms of violence, perhaps because schools are a key setting for violence to occur. Also, schools provide a structured setting where students spend a significant portion of their time, making it a convenient location to implement prevention programs and, at the same time, reach a broad and diverse audience. Additionally, interventions implemented within the school setting can target not only individual students in the classroom but also groups of students, enabling schools to utilize a range of strategies to address various forms of violence, including peer mediation programs and cooperative approaches. They often involve teachers or school staff in delivering the intervention and can be integrated into the school curriculum, as is the case of the KiVa program (Kärnä et al., 2011; Valenzuela et al., 2022), the SMART talk (Bosworth et al., 1998, 2000), and the CP-IE Coping Power Internet-enhanced (Lochman et al., 2017). Interestingly, two programs included in the review used a community-based approach (Oscos-Sanchez et al., 2021), which focuses on engaging community members, organizations, and institutions in promoting safe and healthy environments for young people. The intervention methodologies were entirely designed during community meetings and involved providing participants with access to online activities that focus on developing creative critical thinking and

self-expression skills. The intervention also includes youth summits held at local high schools, thus providing opportunities for young people to engage in activities that promote positive relationships, respect, and healthy behaviors, which can, in turn, reduce the risk of violence.

Digital Strategies

The current review highlighted that several digital strategies have been employed as digital interventions to tackle diverse forms of youth violence. These encompass computer-based, internet-based, mobile app-based, and virtual reality. More specifically, computer-based interventions have been the earliest to be implemented and have been commonly used for all three types of violence prevention over the years. These kinds of interventions were primarily designed as interactive digital games (e.g., Bosworth et al., 2000; Garaigordobil & Martínez-Valderrey, 2018; Rončević Zubković et al., 2022), incorporating realistic scenarios, role-playing, decision-making, problem-solving, and feedback mechanisms to engage the user and reinforce positive behaviors. Recently, virtual reality systems have emerged as a novel intervention modality for youth violence prevention, particularly in the context of bullying, with notable applications starting as early as 2019. These interventions use virtual reality technology to engage youth in interactive games, including role-playing exercises and social skills training (Alsem et al., 2021; Gu et al., 2022), or to simulate immersive bullying scenarios that teach users how to respond assertively and empathetically (Barreda-Ángeles et al., 2021; Ingram et al., 2019).

Targeted Skills

The findings of the current review indicate that digital interventions aimed at preventing youth violence generally target common skills while also including specific skills related to the type of violence being addressed. Commonalities concern promoting key abilities such as conflict resolution, emotion regulation, knowledge and awareness, empathy and prosociality, and self-efficacy. Interventions that specifically target and develop these skills have shown compelling evidence, demonstrating their effectiveness in promoting positive change and strengthening prevention efforts against youth violence as a whole. By prioritizing conflict resolution, problem-solving strategies, and other-oriented attitudes, interventions empower young individuals to resolve conflicts constructively and navigate challenging situations without resorting to violence. Additionally, by teaching youth how to manage and regulate their emotions, interventions enable them to effectively handle difficult situations, thus reducing the likelihood of aggressive or violent behavior. Knowledge and awareness also play a crucial role in preventing youth violence. Interventions that focus on providing information about violence and its consequences increase awareness among young individuals, empowering them to make informed choices and avoid engaging in violent behaviors. Furthermore, by fostering empathy, interventions help young individuals understand others' feelings and perspectives, encouraging caring behavior, positive interactions, and healthy relationships. Finally, interventions that target self-efficacy may help enhance young individuals' belief in their ability to engage in prosocial behaviors and desist from engaging in violent behavior. By building self-confidence and a sense of personal agency, these interventions empower youth to resist peer pressure and make responsible decisions.

Regarding the specificities of the digital interventions examined, the findings provide insight into the precise content areas that each intervention primarily focuses on when addressing knowledge and awareness skills to prevent the different forms of violence. In the case of bullying and cyberbullying, the interventions primarily aim to increase youth knowledge about the nature of bullying itself and provide them with the necessary information to recognize bullying situations. For interventions targeting intimate partner violence, the focus lies on recognizing healthy and unhealthy relationships and actively preventing gender norms and attitudes that can lead to the perpetration of violence within intimate relationships.

Overall, recognizing and leveraging the commonalities and specificities in digital interventions addressing different forms of violence might prove to be crucial in the development of comprehensive and impactful preventive measures. By implementing this approach, youth can develop key abilities to cultivate healthy relationships based on respect and fairness, thereby reducing their likelihood of engagement in various forms of violence.

Intervention Effectiveness

Overall, the evaluation studies for general aggression demonstrate the potential of digital interventions to prevent youth from engagement in violence. These interventions leverage unique properties such as engagement, attractiveness, and feasibility to simulate real-world experiences, providing users with opportunities to learn and practice new skills. Furthermore, the findings suggest that various types of digital interventions, including interactive games, online activities, and video trainings, can effectively prevent youth engagement in violent behaviors. Further, the effectiveness of the TakeCARE intervention in increasing positive bystander behavior among high school students suggests the value of bystander training programs based on technology (Jouriles et al., 2019). By focusing on promoting bystander intervention and developing self-efficacy, such interventions

can contribute to creating safer and more supportive social environments.

As regards the interventions targeting bullying, the findings are overall encouraging and suggest that gaming and virtual environment may be promising tools for future interventions (Holt et al., 2016). In general, game-based interventions have shown promise in improving knowledge, attitudes, social skills, coping strategies, and intentions to act as proactive bystanders. Additionally, virtual reality and immersive formats have demonstrated positive effects in increasing empathy, sense of school belonging, and willingness to intervene as active bystanders. However, several considerations need to be highlighted in this respect. Firstly, the studies reviewed mainly focused on measuring changes in intentions, attitudes, and other relevant skills, indicating that the interventions were overall effective. However, there remains a notable gap in research when it comes to directly assessing actual behavior, which limits our comprehensive understanding of bullying reduction. Furthermore, the evidence gathered thus far suggests that not all interventions are equally successful in reducing bullying perpetration. These mixed findings suggest the need for careful evaluation and refinement of intervention approaches to ensure effectiveness. Secondly, the context in which interventions are implemented has emerged as a potential source of influence on effectiveness. For instance, the varying results of interventions like the "KiVa Program" across different cultural contexts highlight the importance of carefully considering cultural factors when designing and implementing anti-bullying interventions.

Research focusing on digital interventions to prevent violence in intimate relationships has produced interesting results. The use of the game "Tsiunas" (Gonzalez et al., 2022) was found to be effective in altering entrenched beliefs related to patriarchal patterns and attitudes toward violence against women. This is an important finding, as such beliefs are often deeply ingrained and difficult to change. The fact that the game was able to influence changes in beliefs in both male and female participants is also noteworthy. The evaluation study of the game-based intervention "It's your game… keep it real" (Peskin et al., 2014) found that it was effective in reducing emotional dating violence perpetration among middle school students. While the intervention did not have a significant impact on physical dating violence perpetration, this is still an important finding, as emotional violence is often overlooked but can be just as damaging as physical violence. The study of the game "JESSE" (Boduszek et al., 2019) found that the intervention was effective in increasing affective responsiveness among teenagers. More specifically, by engaging with the game's narrative, which revolves around a child witnessing violence inflicted by their father upon their mother, players are immersed in a compelling storyline that has demonstrated to have the potential to evoke a heightened sense of empathy and sensitivity towards the effects of violence on individuals and families. Developing such empathy is crucial, as it can lead to a significant shift in attitudes and behaviors among teenagers, therefore preventing them from engaging in violent behavior. Furthermore, this can empower them to break the cycle of violence that might arise through observational and social learning processes (Bandura, 1973). Finally, using video teaching and internet-based learning was found to be effective in improving attitudes toward healthy conflict resolution and reducing dangerous attitudes that lead to violence in intimate relationships (Nagamatsu et al., 2021). This finding supports the idea that the video teaching approach can be a useful tool to prevent youth violence because it is accessible, cost-effective, and can be delivered in a variety of formats, such as online platforms, DVDs, or broadcast media. It can also be easily adapted to different age groups and cultural contexts and can be integrated with other educational and prevention programs.

Gaps and Future Directions for Research and Intervention

Although this review has highlighted some positive findings, it is important to acknowledge the gaps in the current evidence that still remain, as well as the insights that can be gleaned from the research conducted so far. First, while technology-based interventions hold great promise for preventing youth violence, the current evidence base is limited in its ability to support their effectiveness. Although many studies assess the impact of intervention programs, few delve into the process of program development (e.g., DeSmet et al., 2018). Specifically, the provision of a clear definition of the target problem and population often gets neglected. Such information is critical as it helps to match the intervention to the problem at hand. The Intervention Mapping Protocol (Bartholomew et al., 2011) highlights the importance of defining the problem and targeting interventions accordingly, as different types of interventions may be necessary depending on the situation. For example, universal interventions offered to all young people may not require a behavioral change outcome if there is no specific behavior that needs to be changed. Selective interventions that target individuals displaying risk factors for violence may focus on addressing those factors rather than violent behavior that hasn't emerged yet. Indicated interventions for individuals already engaged in violent behavior may focus on preventing recurrence or reconviction. Defining the problem accurately and measuring it correctly is crucial and enable researchers and practitioners to develop interventions that are more likely to be effective in addressing the specific needs of the target population. With this respect, it is also important to evaluate the factors that moderate the effectiveness of youth

violence interventions. Improved evaluation efforts are necessary to better understand what approaches are effective and for whom, as well as why certain approaches work while others do not (Gottfredson et al., 2015).

In addition, some of the studies examined lack a rigorous evaluation of the interventions. They do not include at least one control group or random assignment of participants, which is the gold standard for ensuring that differences in outcomes can be attributed to the intervention rather than other factors (Gottfredson et al., 2015). Also, they often have small sample sizes and short follow-up periods. Therefore, it is imperative that future studies conduct extensive and methodologically rigorous studies that comprehensively assess the effectiveness of digital interventions in preventing and reducing youth violence over an extended period. Only through such efforts is it possible to identify and implement evidence-based strategies that can make a meaningful impact in creating safer and healthier communities for youth. Also, the issue regarding the paucity of behavioral and observational measurements in the evaluation studies of intervention effectiveness, coupled with the overreliance on measures of specific abilities and attitudes, represents a significant gap that deserves increased attention in future research. While these measures provide valuable insights into participants' perceptions and self-reported changes, they may not always accurately reflect real-world behaviors and actions. A more comprehensive approach will not only strengthen the evidence base but also provide a more robust understanding of the effectiveness and impact of interventions in reducing aggressive or violent behavior among youth.

To effectively prevent and reduce youth violence through digital interventions, the current review outlines that it is crucial to acknowledge and account for the influence of cultural norms and values on how people perceive and respond to these interventions. Further in detail, the review identified two key aspects of this influence. Firstly, cultural differences can greatly impact the feasibility and effectiveness of digital interventions. Therefore, to maximize their impact, it is crucial to tailor interventions to local contexts, taking into account the unique cultural heritage and beliefs of the target population, and providing a culturally resonant experience that can promote meaningful engagement and positive behavior change. Collaboration with local communities and stakeholders is highly recommended to ensure cultural appropriateness and effectiveness, since failure to consider these factors can undermine the potential impact of digital interventions on preventing and reducing youth violence. Secondly, cultural contexts themselves play a vital role in informing the specific types of youth violence that should be targeted for intervention. Different cultures may have varying prevalence rates, patterns, and underlying causes of youth violence, which necessitate tailored approaches to address these specific issues effectively. For instance, when considering interventions for intimate partner violence, this review outlined that there tends to be greater cultural heterogeneity compared to interventions targeting other forms of youth violence. This might be due to the fact that intimate partner violence is influenced by complex dynamics related to cultural norms, gender roles, power dynamics, and social expectations, which vary significantly across cultures. Therefore, by recognizing the cultural diversity among different types of youth violence interventions and tailoring them to align with the cultural nuances and sensitivities associated with each type, interventions can become more effective in addressing the distinct challenges and meeting the specific needs of diverse populations.

Additionally, it is concerning that many of these interventions are no longer available or are only partially accessible to users. This can be due to several reasons, such as lack of funding, limited resources, or technical difficulties. Such limitations prevent users from accessing potentially beneficial interventions and can impede progress in the field. To ensure that digital interventions continue to advance, it could be crucial for policymakers to prioritize increasing funding for research and implementation programs specifically focused on youth violence prevention while also addressing issues of availability and accessibility. Additionally, fostering collaborations among researchers, practitioners, and technology developers would enable the incorporation of emerging evidence and best practices into intervention designs, ensuring their longevity and sustained accessibility. Finally, it is important to raise public awareness about the availability and benefits of digital interventions for youth violence prevention. Only through such efforts, the full potential of digital interventions can be realized, and their benefits be made available to those who need them most.

As digital interventions become more prevalent in preventing youth violence, it is essential to consider the ethical implications of these interventions. Issues such as privacy and data security must be given the utmost importance in designing and implementing these interventions. By doing so, it can be ensured that digital interventions are not only effective but also designed and implemented in an ethical and responsible manner. If left unaddressed, this could not only cause harm to those involved but also damage trust in the interventions and diminish their capacity to make an impact.

Overall, future research in this field should focus on developing and testing interventions that are engaging, interactive, and tailored to the needs and preferences of the target population. This can involve the use of emerging technologies, such as artificial intelligence, virtual reality, and gamification, to create interventions that are more immersive and personalized.

Limitations

This systematic review has several limitations that must be considered when interpreting the findings. Firstly, the review is limited by the search terms used, databases included, and the temporal window during which the searches for articles were carried out, as is common in all systematic reviews. Secondly, it is important to note that the studies included in this review exhibit a wide range of heterogeneity in terms of the intervention designs, target populations, and outcomes measured, which may limit the generalizability of the findings. While this heterogeneity might be reasonably attributed to the rapid advancement of technology over the past 25 years, the diverse nature of the included studies implies the importance of considering the specific features and conditions of each intervention when interpreting the findings. Also, the significant variations in terms of intervention types, populations, study designs, and methodologies, combined with the lack of direct comparability among measured outcomes, made it challenging to perform a meaningful meta-analysis and effectively combine the results. Future research could explore the possibility of conducting a meta-analytic study that focuses on a narrower selection of studies sharing commonalities, such as assessing comparable outcome measures. This approach would provide meaningful insights to guide future research and interventions in a more targeted manner. Thirdly, while this review focuses on interventions targeting the specific challenges and needs of children and adolescents, it is important to note that the inclusion of young adulthood could provide valuable insights into the effectiveness of the interventions to prevent youth violence as individuals transition into adulthood. Therefore, future research should explore violence prevention efforts that extend to young adulthood to further understand the trajectory of violence prevention across the lifespan. Finally, this review only included studies published in English, which may have limited the scope of the review and the generalizability of the findings. Future reviews may consider including studies in different languages to provide a more complete synthesis of the available evidence.

Conclusion

Although several studies have examined different aspects of digital interventions targeting youth violence, a significant gap persists in the form of a comprehensive synthesis that harmonizes and integrates their findings. This review aimed to fill this research gap by providing insights into the current landscape, emerging trends, research gaps, methodologies, and the effectiveness of strategies that leverage digital platforms and technologies to address youth violence. Overall, the findings indicate that a variety of digital strategies, such as interactive games, online activities, and video training, can effectively be used to prevent violence among young individuals. This demonstrates the versatility and effectiveness of utilizing different forms of technology in addressing youth violence. By targeting common skills such as conflict resolution, emotion regulation, prosocial attitudes, and self-efficacy, digital interventions can equip children and adolescents with the necessary tools to navigate challenging situations and avoid involvement in various forms of violence. Finally, virtual and immersive environments have shown promise as tools for interventions targeting violence. Noteworthy, these technologies have demonstrated potential for overcoming the challenges encountered in face-to-face interventions in preventing bullying among middle and high school students. When designing and implementing interventions, it emerged as imperative to thoroughly consider conducting comprehensive evaluations, integrating cultural factors, and addressing accessibility issues. This approach is essential in creating interventions that are not only effective but also culturally appropriate and accessible, ultimately leading to greater impact and broader reach.

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Declarations

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*An asterisk denotes publications that were included in the review

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